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ON THE GEOLOGICAL AGE AND EQUIVALENTS OF THE MARSHALL GROUP.

BY PROF. A. WINCHELL.

CONTENTS.

I. The existence of controversy.
II. History of discovery and opinion.
III. Present state of our stratigraphical knowledge.
  Tables of stratification in various States.
    Parallelism of these strata.
    The Black Shale.
    The Carboniferous Conglomerate.
    The strata between the Conglomerate and the Waverly series.
    The Waverly series and its equivalents.
    Not synchronous with Portage and Chemung.
    Huron Group synchronous with Portage and Chemung in Michigan, Ohio, Kentucky, Iowa.
    This synchronism consistent with the tenor of Geological History.
IV. Present state of our paleontological knowledge.
  Characters and parallelism of the Huron Group.
  Catalogue of fossils from the Marshall Group and its equivalents.
  Discussions of the catalogue.
    Relations of Western localities among themselves.
    Relations of these to Portage and Chemung.
    Relations of the same to Conglomerates of western New York.
V. The Fauna of the Marshall Group presents a Carboniferous aspect.
  Fossils identified with Carboniferous species of America and Europe.
  Fossils whose analogies recur in Carboniferous rocks.
  Generic and subgeneric types of a Carboniferous character.
VI. The Fauna of the Chemung Group presents a Devonian aspect.
VII. Can the Marshall and Chemung Group be synchronized?
  Reliability of fossils in determining parallelism.
  The Marshall and Chemung cannot be synchronized.
  Influence of geographical conditions.
VIII. Parallelism of the Catskill and Marshall Groups.
  Objections considered.
  Paleontological affinities of the two.
  Table of geological equivalents.
IX. Their names.
  Appendix. References to publications on the subject.

I. EXISTENCE OF CONTROVERSY.

Every person conversant with the history of American geological science is aware of the controversy which has long existed in reference to the age and equivalents of the strata lying between the Corniferous limestones and the limestones of the Lower Carboniferous system. Geologists of the highest ability—both American and European—have participated in the discussions; and western geologists, almost without exception, have been constrained to commit themselves, for specific reasons, to definite, though often diverse, views in reference to the geology of the zone in question. As additional facts have been successively brought to light, some important progress has been made in the settlement of controverted points; and the great body of western geologists seem to have united with considerable unanimity in a judgment upon the main issues. Very persistent opposition is manifested, however, in certain quarters, to the verdict which is already shadowed forth; and there are probably few whose convictions have been satisfactorily and finally settled by a comprehensive comparison of the facts which have been collected. I think, therefore, it may be useful, in the present state of opinion, to bring forward a review of the data upon which the controversy has proceeded, and to furnish the grounds of the convictions which for some years past have been strengthening in my own mind. In doing this, I hope I shall be actuated by a spirit of candor, and sentiments of profound respect for the distinguished names arrayed against my position. I seek only the truthful determination of the question; and I would not raise my voice in a discussion where so many worthier ones have been heard, did I not recall to mind that the merest child, or the humblest peasant may stumble upon phenomena which the philosopher had long sought in vain, and which may serve as the solvent of chronic and distressing doubts.

II. History of Discovery and Opinion.

So far as I have observed, the first distinct allusion by any geological writer to the zone of rocks under consideration, is embraced in an elaborate description of the topography and geology of the "bituminous coal deposits of the valley of the Ohio, and of the accompanying rock strata" by that distinguished pioneer of western geology, Dr. S. P. Hildreth.[1]

In the section which he has given of the "Ferruginous deposits,"[2] it would appear that the lower beds, 500 feet in thickness, extend into the series afterwards designated the "Waverly series" by the Ohio geologists. Dr. Hildreth styles them the "Great Lias Rock," and afterwards an "Argillaceous sandstone rock, very fine grained," &c. Dr. S. G. Morton appends to this paper descriptions and figures (mostly too imperfect for identification) of several species of included fossils.

In 1838, Mr. C. Briggs,[3] assistant upon the geological survey of Ohio, bestowed the name "Waverly Sandstone Series" upon the lower portion of the succession of shales, sandstones, and shaly sandstones, interposed between the so-called Black Slate and the great Carboniferous Conglomerate. The series took its name from the village of Waverly in the southern part of the State in Pike county, since some of the most beautiful building stones afforded by the series had been quarried at that place. The Ohio geologists, however, in other and subsequent publications, generally referred to this assemblage of strata under the designation of "Fine Grained Sandstone Series."[4] The lower limits of the series, as defined, were distinctly marked by the horizon of the Black Shale; but the upper limits were not stated with precision. It does not appear however that the series was originally supposed to reach upwards to the Conglomerate;[5]

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[1] Amer. Jour. Science and Arts, vol. 29, p. 1, and Plates 1 to xxxvi.

[2] Ib. p. 133; also 136.

[3] First Ann. Rep., Ohio, p. 79.

[4] See for instance "Report of Special Committee to report on the best method of obtaining a complete geological survey," 1836, p. 13, where the expression seems to have been first employed; Whittlesey, Second Ann. Report, 1838, p. 56; J. W. Foster, Ib. p. 76; Briggs, Ib. pp. 122, 130.

[5] Whittlesey, 2d Ann. Rep., p. 56.

though the Ohio geologists appear eventually to have given the term "Fine Grained Sandstone Series" that extension of meaning; and Col. Whittlesey, Prof. Hall, Dr. Newberry and others, have since treated the term "Waverly series" as synonymous. The Ohio geologists abstained, on principle, from expressing any opinion on the subject of the American or foreign equivalents of these rocks.

During the same year, Mr. J. W. Foster[6] made a report in which he described the Fine Grained Sandstone of Licking and Franklin counties, as a continuation of the Waverly series of Briggs, and expresses the opinion that it is "a member of the mountain limestone formation." I direct particular attention to this early judgment. It must be noted, however, that the older Cliff Limestone was also at that time regarded as belonging to the mountain limestone series. Both Foster and Briggs speak of the paucity of organic remains in the lower portion of the series, and their abundance in the upper portion.

The public geological survey of Michigan was inaugurated at about the same time as that of Ohio. The earliest mention of sandstones in that State, occupying a position in the zone under consideration, is found in Dr. Houghton's report for 1838.[7] Under the head of the "Upper Sandstone of the Peninsula," he notices those rocks which I have designated[8] the "Woodville Sandstone" above the coal; the "Parma Sandstone" beneath it, and those portions of the "Marshall group" which outcrop in the southern counties. The outcrop of the last named sandstones in the vicinity of Pt aux Barques, east of Saginaw bay, is treated by Dr. Houghton in connection with the Lake Superior Sandstone under the head of "Lower Sandstone or Graywacke group" (p. 9).

In the report of the following year, the Marshall sandstones are again stated by Dr. Houghton to belong to "the great carboniferous group of rocks."[9]

The first attempt at a systematic account of these strata was made in 1840 by Bela Hubbard,[10] assistant on the geological survey. Mr. Hubbard correctly apprehended their position as beneath the coal producing strata, and alluded to the richness of the lower beds in organic remains. *The deeper and more argillaceous strata were never, in southern Michigan, associated as in Ohio, with the newer and more arenaceous beds.* The entire series of argillaceous strata, including the black shale of the state, which is very inconspicuous in the southern counties, were described by Hubbard as the "Kidney Iron Formation." This was regarded as the bottom of the Carboniferous system. The northern outcrop of these groups were reported upon in 1841.[11] In his attempt to assign them to their proper stratigraphical position, Mr. Hubbard fell into singular errors, and introduced into the most elaborate account of the lower peninsula which was destined to be published for twenty years, a confusion of facts which rendered the geology of Michigan an enigma to every one who attempted to parallelize the rocks with those of surrounding States.[12] The following is Mr. Hubbard's tabular statement of the succession of groups embraced in the lower peninsula,

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[6] Second Ann. Rep. Geol., Ohio, p. 103.

[7] First Ann. Rep. Geol. Mich., p. 3.

[8] First Bienn. Rep. Mich., 1861.

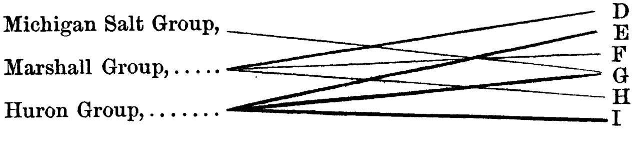
[9] Mich. Geol. Rep., 1839, p. 28.

[10] Mich. Geol. Rep., 1840, p. 87.

[11] Mich. Geol. Rep., 1841, p. 114.

A. Erratic Block group or Diluviums,
B. Tertiary Clays,
C. Coal measures,
D. Sub-carboniferous Sandstones,
E. Clay and Kidney Iron formation,
F. Sandstones of Pt aux Barques,
G. Argillaceous slates and flags of Lake Huron,
H. Soft, light-colored Sandstones,
I. Black, aluminous slate,
K. Lime rocks of Lake Erie.[13]

In this table, as we now know, the groups marked D, F, and H, are but different outcrops of the Marshall group; and those marked E, G, and I, but different outcrops of the Kidney Iron or Huron group. Following Dr. Houghton in the report of 1838, Mr. Hubbard regarded the Pt aux Barques sandstones and conglomerates as occupying a position beneath the Kidney Iron formation of the southern portion of the state, and consequently failed to identify the underlying shales. In the next place, Mr. Hubbard identified with the Pt aux Barques shales, the shales of the "Michigan Salt group," struck in the salt wells at Grand Rapids, although these latter actually occupy a position above the Marshall sandstones. When, therefore, these sandstones and the underlying Huron shales were struck in the boring of the salt wells, they were supposed to constitute the third couplet of similar strata, and are set down as groups H and I, in the above table.[14] This confusion is illustrated by the following diagram:



The Pt aux Barques sandstone were rightly recognized by Hubbard as the equivalent of the characteristic portion of the Waverly sandstone series in Ohio; and it is singular that they were not observed to be equally identifiable with the sandstones of Hillsdale county in the southern part of the state. The upper conglomeratic portion of the Pt aux Barques sandstones was erroneously synchronized with the Carboniferous conglomerate, which though reposing on the Waverly of Ohio, is separated from the equivalent Marshall in Michigan, by the Carboniferous limestone and the Michigan Salt group. The Black Shale was also recognized as agreeing "in general character *and position*" with "the Black Shale stratum of Ohio and Indiana." [15]

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[12] In his attempt, in 1843, to parallelize the strata of Michigan with those of other states, Prof. Hall assigned the Pt aux Barques series to the zone of the Waverly Series and the Portage and Chemung; but he seems not to have known how to dispose of the rocks denominated by Houghton and Hubbard the "Upper Sandstone of the Peninsula." Rep. Geol., 4th Dist. N. J., p. 519.

[13] See also Report, p. 136.

[14] Report, p. 133.

In 1841, when Professor Hall was closing up his labors upon the geology of Western New York, he undertook an extended tour through the western states for the purpose of ascertaining to what extent the formations recognized in New York could be traced in other regions. The general results of this tour were announced in 1842.[16] At this time, he was led to regard the Waverly series (embracing everything between the Black Shale and the Conglomerate), as a prolongation of the Chemung and Portage groups of New York. The thick bedded sandstones at Newburg and Waverly were identified with the Portage sandstones, while the shaly sandstones and flags near Cleveland were regarded as representing the Gardeau shales and flagstones. From Newburg to Cuyahoga Falls, and also at Akron, he identified the shales and sandstones of the Chemung group.

Passing down the Ohio into Indiana, Prof. Hall again identified strata corresponding to the Portage, and doubtfully to the Chemung; while above these, and beneath the carboniferous limestone, was a series of arenaceous strata becoming interstratified above with beds of mountain limestone, and, on the whole, exhibiting affinities with the Carboniferous system. Nevertheless he inclined to regard them as "sub-carboniferous" (used in the sense of *subter-carboniferous*,) remarking that "a limit should be fixed between what is to be strictly referred to the Carboniferous period, and older deposits." [17] The Black Shale of Ohio and Indiana was regarded by Professor Hall as the equivalent of the Marcellus Shale of New York "being the only representation of that rock, the Hamilton group and the Genesee slate" (Ib. 280).

During the same year, Mr. Conrad[18] read a paper before the Academy of Natural Sciences of Philadelphia, in which he embraced brief descriptions of three fossils from the Marshall sandstone of Moscow, Michigan, which he referred to the Carboniferous system. Mr. Vanuxem's Report on the Geology of the Third District of New York, also appeared this year.

In 1847 the distinguished European geologist, de Verneuil, gave the world the results of an extended and critical investigation of the parallelism existing between American and European paleozoic formations.[19] This paper was translated and somewhat condensed by Professor Hall for publication in America.[20]

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[15] It is interesting to note this early identification of the now styled Marshall sandstones with the characteristic portion of the Waverly sandstone series; and the Black Shale of Michigan with the Black Shale of Ohio and Indiana; as these opinions were expressed by Hubbard anterior to the first elaborate attempts by Hall and de Verneuil to trace the parallelism of formation in the different states. Dr. Houghton had, indeed, previously recognized the correspondence of the "Black Shale" with certain formations in western New York, as described in the annual reports of that State; though there is room to doubt whether he made the identification preferably with the Marcellus or the Genesee Shale. Under the great natural difficulties attending the exploration of the "wilderness of Michigan," then just emerging from a territorial condition, and the equally great embarrassments resulting from the undisturbed condition of the strata, it is indeed remarkable that the early geologists of the state succeeded in establishing so many conclusions which have stood the test of nearly a third of a century.

[16] Amer. Jour. Sci. and Arts, xlii p. 51; Jour. Bost. Soc. Nat. Hist. v. p. 1, and more fully in Trans. Assoc. Amer. Geol., p. 267. See also Geol. Rep., Fourth Dist. N. Y., p. 229.

[17] Trans. Assoc. Am. Geol., p. 281.

[18] Jour. Acad. N. S., Phil., vol. viii, p. 249 and 269.

Professor Hall's translation is accompanied by criticisms and additions.[21] One of the results of de Verneuil's studies was to lower the base of the Devonian system from the bottom of the Portage group where it had been placed by Conrad, to the bottom of the Oriskany sandstone, and to fix the summit above the Catskill group. He recognized the prolongation of the Portage and Chemung groups into Ohio, but did not detect them in Indiana, Kentucky, and Tennessee; though Prof. Hall in his notes upon the paper, was inclined to recognize them in Indiana above his and Owen's "sub-carboniferous." The upper, or fossiliferous portion of the Waverly series was regarded by de Verneuil as falling within the limits of the carboniferous system. The Black Slate of the West was identified with the Genesee Shale of New York. These conclusions are fortified by extended paleontological comparisons.

Professor Hall in his commentary upon this elaborate paper, seems to oscillate between two opinions. He insists at one time upon the Silurian relationships of the Hamilton, Portage and Chemung, and the broad lithological and paleontological gap intervening between the Chemung and the Catskill,[22] intimating that there is the place to draw the systemic lines; while at another time he asserts that the Chemung is more intimately "related to the Carboniferous sandstones of the West than the Hamilton group of New York"[23]—that "there is no well defined line of separation between the Chemung rocks of New York, and the sandstones of Ohio and Indiana, which contain carboniferous fossils"—and that "the error of American geologists who have attempted to compare our formations with those of Europe, has been, in this instance, that of regarding the great Carboniferous limestone as forming the basis of that system, including all the strata below it in Devonian and Silurian."[24]

In 1848 Mr. Murray, of the geological survey of Canada, made an examination of black bituminous shales on the south-east shore of Lake Huron at Kettle Pt., and described them[25] under the head of "Hamilton group," remarking that they contained *Lingula*, but "neither of the two species represented by Mr. Hall as belonging to the Genesee slate." Mr. Murray adds that "no trace of the sandstones [of the Portage and Chemung groups] . . . has yet been met with in western Canada."

[19] "Sur le parallélisme des dépots paléozoïques de l'Amerique Septentrionale avec ceux de l' Europe; suivie d' un tableau des éspèces fossiles communes aux deux continents, avec l' indication des étages où elles se rencontrent, et terminée par un examen critique de chaque de ces éspèces." Bulletin de la Soc. Geol. de France. 2me Ser. Tome, iv, p. 646.

[20] Am. Jour. Sci. and Arts, [2] vol. v. pp. 176 and 359 and vol. vii. pp. 45 and 218.

[21] See further critical remarks by Sharpe, "On the Paleozoic Rocks of N. A.," in Quar. Jour. Geol. Soc. Lond., Aug. 1848, and a paper by Mr. Elle de Beaumont, entitled "Note sur les systémes de Montagnes les plus anciens de l' Europe."

[22] Amer. Jour. Sci., [2] v. 367, Note; vii, 46, Note 3 and p. 231. He had previously pointed out the break below the Catskill. Pal. N. Y., vol. 1, introd. p. xvi.

[23] Amer. Jour. Sci., [2] vii, p. 46, Note (a,)

[24] Amer. Jour. Sci., [2] vii, 45, Note.

[25] Report of Progress, 1848-9, p. 24.

In 1850 Professor Hall resumed the discussion of the parallelism of eastern and western formations, and the parallelism of the whole with the standard systems of Europe.[26]

In this celebrated discussion, Professor Hall states that "the shales and sandstones of the Catskill mountains, . . . have no representatives at the West. Succeeding the Black Shale, however, there is a group of shales and sandstones which, from the fossils they contain, are regarded as belonging to the Carboniferous period."[27] And again, "the green shales and sandstones of Ohio and Indiana, which succeed this Black Shale, have been recognized as carboniferous by their fossils, though there is still some doubt whether the lower part may not represent the Chemung group of New York."[28] He still insists on the carboniferous aspect of the rocks from the Marcellus to the Catskill, and cites, after de Verneuil, the *Goniatites rotatorius* and *Goniatites princeps* as proving the carboniferous age of the "Rockford bed" which he regards as embraced in the Marcellus shale.[29]

About the same date, Mr. Murray[30] reported new observations on the Black Shales of Canada West, in the region more recently famous for its production of petroleum. These he still regarded as embraced in the Hamilton Group, and probably continuous with those previously examined at Kettle Point. He remarks that the "bituminous springs [of Enniskillen] probably owe their origin" to this formation.

In 1851, Mr. Christy[31] read a paper before the American Association at its Cincinnati meeting, in which he announced that the Rockford Goniatite limestone is centrally located in the Black Slate of Indiana, and according to Verneuil embraces the carboniferous fossils *Goniatites rotatorius* and *G. princeps*, and *Cyclolobus*. Mr. Christy specifies several localities at which the limestone and the slate may be seen in juxtaposition, and accounts for Dr. D. D. Owen's error in pronouncing the limestone a portion of the Cliff limestone. Mr. Christy states that the Goniatite limestone has about 28 feet of black shale below it, and about 30 feet of black shale above it. The latter is succeeded by "about 350 to 400 feet of soft shale with an occasional stratum of limestone and some beds of sandstone, including fossils."[32]

At the same meeting Col. Whittlesey[33] read a paper "On the equivalency of the rocks of north-eastern Ohio, and the Portage, Chemung, and Hamilton rocks of New York." Col. Whittlesey's extended and accurate observations in the state, enabled him to furnish valuable sections of the Ohio strata, to which I shall have occasion again to refer. Following Professor Hall in his paper published in 1842, he places the Ohio rocks, from the Cliff limestone to the Conglomerate, in the zone of the New York Upper Devonian.

In 1852 Dr. D. D. Owen[34] published a geological map of the North-west,

[26] Foster and Whitney's Rep. Min. Land District, L. Sup., vol. ii., chap. xviii, p. 285.

[27] Ib. p. 292.

[28] Ib. p. 307.

[29] Ib. p. 309.

[30] Rep. Progress Geol. Sur. Can., 1850-51, p. 29,

[31] Proc. Amer. Assoc., vol. v., p. 76.

[32] Ib. p. 80.

[33] Ib. p. 207.

[34] Geol. Rep. Wis. Iowa, and Minn.

in which he colored as Carboniferous, all those regions in Missouri and Iowa underlaid by rocks intervening between the Carboniferous limestone and the Black Slate. Dr. Owen embraced in the Mountain limestone series, the yellow sandstone at the base of the exposure at Burlington, Iowa, and from the associated oölitic bed he describes and recognizes *Producta Cora, Spirifera striata* and *Cryroceras Burlingtonense* (Ib. p. 95).

Professor Swallow[35] in his Missouri Report, published in 1855, recognizes the Chemung group, and establishes three divisions called respectively, in descending order, the "Chouteau limestone," the "Vermicular sandstone and shales," and the "Lithographic limestone." Professor Swallow in referring to differences of opinion about the age of these rocks, says: "Many of our fossils are either identical with, or very similar to those of the Chemung group of New York. Among these are a species of those remarkable forms of the New York reports called *Fucoides cauda-galli?* and *Filicites gracilis;* also *Avicula subduplicata* and *Nucula bellatula.* Mr. F. B. Meek[36] in his appendix, enumerates 55 species of fossils from these rocks, of which 19 are described by Dr. B. F. Shumard as new species; 13 are identified with European carboniferous species, while one only, *Avicula duplicata* (Hall,) is identified with species from the Chemung of New York, and two—*Spirifera mucronata?* and *Nucula bellatula,* are identified with Hamilton species. Such determinations would seem to afford but slender support to Professor Swallow's decision, to range these rocks on the horizon of the Chemung.

During the same year Mr. Marcou[37] reproduced in Europe the geological chart of the United States, which he had first published in America[38] in 1853. In this chart he colors as underlaid by the Mountain Limestone, the entire area in Michigan which we now know to be occupied by the Marshall and Huron groups. The area of the Waverly series is colored as Devonian. This chart was again reproduced in 1858[39] with alterations, at which time, Mr. Marcou seems to have regarded the area of the Marshall group in Michigan as also of Devonian age.

Norwood and Pratten[40] in 1855, in describing *Chonetes Fischeri* from the yellow sandstones at Burlington, Iowa, refer them to the "base of the Mountain Limestone."

The "Knobstone" formation of Kentucky was ranged by D. D. Owen[41] in 1856, as "sub-carboniferous"; while the "Black Singula Shale," as he styles it, was regarded as Devonian.

Professor Safford[42] in the same year advanced the opinion that the Black Shale of Tennessee ought to be regarded as Carboniferous.

In Mr. Murray's[43] Canadian report for the year 1855, he decides to transfer the Black Shale of Canada West to the "Portage and Chemung group;" assigning as his motive the fact that "Professor Hall, on seeing the section at Kettle Pt., expressed it as his opinion that the rocks were the lowest measures of the Portage and Chemung group," and the fact that "a nearly complete section of the Hamilton group" had been discovered on "some of the tributaries of the River Sable (south)."

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[35] Rep. Geol. Surv. Mo. I., p. 101.

[36] Ib. II, p. 218.

[37] "Geol. Karte d. Verein· Staaten," in Peterm. Mittheilungen, p. 149.

[38] Geol. Map of U. S., with explanatory text.

[39] Geology of North America, with Maps and Plates, Zurich.

[40] Jour. Acad. Nat. Sci., [2] vol. iii, p. 25.

[41] Geol. Rep. Ky., vol. 1. p. 89.

[42] Geol. Reconnoissance Tenn., p. 158.

[43] Rep. Geol. Surv. Can., 1853 6, p. 129.

The ferruginous shales of the Marshall group of Michigan were again pronounced Carboniferous in 1858, by Dr. R. P. Stevens,[44] who described from Battle Creek three species of *Leda* and one species each of *Nucula* and *Chonetes*. These are spoken of as occurring in "association with an *Orthoceras*, *Nautilus*, and *Bellerophon Urei*, which is evidently carboniferous."

In the same year, Professor Hall[45] published his Report on the geology of Eastern Iowa, in which he embraced the first separate account which I have observed of the yellow sandstones which outcrop on the banks of the Mississippi at Burlington and other localities. He speaks confidently of their equivalency to the Chemung rocks of New York, and points out a bed of green shale at the base, which he thinks might represent the Portage group. He does not fail to recognize, however, the imperceptible graduation of these sandstones into the overlying Burlington limestone, and expresses the opinion that the Chemung group of Missouri, as organized by Professor Swallow, "will probably be found to include a portion of the Hamilton group."[46] Professor Hall describes eleven species of fossils from these strata, but makes no identifications with fossils from the typical Chemung of New York. Mr. C. A. White's "sections" of the rocks at Burlington, in the appendix to this report, possess very great interest, as embodying the results of exact observations.

In September, 1860, Messrs. Meek and Worthen[47] published descriptions of five new species of fossils from the Rockford limestone. In the same month, Mr. C. A. White[48] published "Observations on the Geology and Paleontology of Burlington, Iowa, and its vicinity;" embracing descriptions of seven new species from the yellow sandstones, and elaborate discussions establishing the intimate relations existing between the yellow sandstones and the overlying Burlington limestone.

During 1859-60-1, a geological survey of the lower peninsula of Michigan was in progress under my direction. The first public announcement of the determinations made upon this survey was in the form of a lecture delivered at the University by myself to an audience consisting mainly of a delegation from the Chicago Academy of Sciences, who were then on an excursion to the University of Michigan. This lecture was reported in full and published in the Chicago Tribune in December, 1860. A summary of the results of the survey was also published in the Detroit Tribune, December 11th, 1860, and briefly in the Detroit Advertiser of January 26, 1861. Advance sheets of my official report were sent off August 18th, 1861, and noticed in the American Journal of Science and Arts in September, 1861.

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[44] Amer. Jour. Sci. [2] xxv., 262.

[45] Geology of Iowa, 1, p. 88.

[46] Ib. p. 91.

[47] Proc. Acad. Nat. Sci. Phil., September, 1860, p. 447.

[48] Jour. Boston Soc. Nat. Hist., vol. vii, p. 209.

In the several documents to which I have just referred, I stated distinctly that I regarded the Marshall sandstones of Michigan as the equivalents of the Fine grained sandstone series of Ohio, and the Black Shale of Michigan as equivalent to the Black Shale of Ohio and Indiana. I also stated as a matter of stratigraphical demonstration, that these black shales are seen in Thunder bay of Lake Huron and in Grand Traverse bay of Lake Michigan to rest *above* the well characterized Hamilton limestones. I had at first considered these black shales as the equivalent of the Genesee Shale of New York,[49] but in deference to the judgment of Professor Hall, personally expressed, I united them with my overlying Hudson group, which was organized to receive a series of bluish and greenish argillaceous strata beneath the Marshall sandstones, and supposed by me to correspond to the Portage group of New York.[50] I was not aware at that time, that Mr. Murray had had an almost identical experience,[51] as I have already stated.

In 1860, Professor Swallow[52] published descriptions of 19 species of fossils from the Chouteau and Lithographic limestones of Missouri ; and in the same year, Mr. Lyon[53] published a section of the rocks of Kentucky, in which he ranges the "Knobstone formation" under "sub-carboniferous," and inclines to place the Black Slate in the same position.

Early in 1861, Professor Hall[54] published "Notes and Observations upon the Fossils of the Goniatite Limestone in the Marcellus Shale of the Hamilton group in the eastern and central parts of the State of New York, and those of the Goniatite beds of Rockford, Indiana, with some analagous forms from the Hamilton group proper." In this paper Professor Hall returns with strong assurance to his original opinion enunciated in 1842, that the Black Shale of the West is the equivalent of the Marcellus of New York, and that the ferruginous sandstones of Ohio and Indiana, are the equivalents of the Portage and Chemung. He describes as new 18 species from the Rockford beds including those recognized as *Goniatites rotatorius*,[55] and *Goniatites princeps* by Verneuil, and two species previously described by Meek and Worthen. He, however, fails to identify a single species from the Rockford limestone with any species occurring in the Marcellus Shale or other Devonian rocks of New York.

The same number of Silliman's Journal which contained the announcement of my official report, contained also a paper by Messrs. Meek and Worthen[56] on the "Age of the Goniatite Limestone at Rockford, Indiana, and its relations to the Black Slate of the Western States, and to some of the succeeding rocks above the latter." These authors deny that any portion of the Black Slate is found above the Goniatite limestone, as had been asserted by Christy, and announced that it lies entirely below. The limestone they identify with the Chouteau limestone of Missouri, founding the opinion on an identification of at least six out of 23 or 24 Rockford species, and a close resemblance amongst most of the others. They argue with a degree of paleontological acuteness which cannot be gainsayed, that both the Rockford beds, and the three members of the Chemung group of Missouri as interpreted by Professor Swallow, present characteristics which forbid their introduction into the Devonian system. They affirm the judgment of de Verneuil, that the Black Slate of the West is the equivalent of the Genesee Shale of New York. In an appended note they propose to adopt the name Kinderhook group for the rocks in Illinois lying between the Black Shale and the Mountain Limestone.

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[49] Mich. Geol. Rep., 1861, p. 78.

[50] Ib. pp. 79 and 139.

[51] In alluding to this fact in my report, I inadvertently attributed this experience to Mr. Billings; Report, p. 79.

[52] Trans. St. Louis Acad. Sci., 1, 635.

[53] Trans. St. Louis Acad. Sci., 1, 620.

[54] xiii. Report New York Regents App., p. 95.

[55] This is described as G. Ixion, in a note, p. 125.

[56] Amer. Jour. Sci.. [2] xxxiii., 167.

Some time in 1862, Professor Hall[57] published a "supplementary note" to his paper on the Rockford limestone, in which he states that having identified the Rockford *Goniatites Hyas* among fossils from the Waverly sandstone of Licking county, Ohio,[58] he is led to "conclude that the position assigned to the Goniatite beds of Rockford may be erroneous, and that the true position is higher in the series, or more nearly in a parallel with the Chemung group."

During the year 1862 large additions were made to our exact knowledge of the species of fossils embraced in the series of rocks immediately underlying the Mountain Limestone. In February, Messrs. White and Whitfield[59] published a paper entitled "Observations upon the rocks of the Mississippi valley, which have been referred to the Chemung group of New York, together with descriptions of new species of fossils from the same horizon at Burlington, Iowa." This paper embraces descriptions of 31 new species. The authors in their introductory remarks, synchronize the yellow sandstones of Burlington, with the Chemung of New York, though admitting the strong paleontological contrast, and their striking affinity with the Burlington limestone and higher carboniferous rocks. This opinion is founded upon the identification of several Iowa and Missouri fossils with species from the Waverly series of Ohio, which is assumed to be in physical continuity with the Chemung of Western New York, as originally alleged by Professor Hall.

In April, Mr. White[60] published further descriptions of new species from the same horizon at Burlington, Iowa; Hamburg, Illinois; and Hannibal and Clarkesville, Mo.; and in the same month Professor Swallow[61] published descriptions of two new species from the Chouteau limestone of Missouri.

In May I published[62] a paper "On the rocks lying between the Carboniferous Limestone of the Lower Peninsula of Michigan, and the limestones of the Hamilton Group, with descriptions of some Cephalopods, supposed to be new to science." Of the species enumerated, 24 were from the Marshall group, and one from the Huron. In this paper the Black Shale

[57] Fifteenth Report New York Regents, App., p. 81.

[58] Having myself examined the fossils, I do not consider it identified with G. Ixion, Meek and Worthen (=G. Hyas, Hall,) but with G. Marshallensis, Winchell, which differs from G. Lyoni by constant technical characters, having an additional accessory lobe and saddle, and having the dorsal lobe broader and relatively longer. A transverse section of G. Lyoni, is broadest near the umbilicus, while a section of G. Marshallensis is regularly oval. Professor Hall's inference, however, remains unchallenged.

[59] Proc. Boston Soc. Nat. Hist. vol. viii, p. 289.

[60] Proc. Boston Soc. Nat. Hist., vol. ix, p. 8.

[61] Trans. St. Louis Acad. Sci., vol. 2, p. 81.

[62] Amer Jour Sci, [2,] xxxiii., 352.

of Michigan and Canada West, were again identified and ranged within the limits of the Huron group, next above the Hamilton.

In September[63] I continued the enumeration of Michigan species from the Marshall and Huron groups, giving 63 from the former, and 17 from the latter. Of the Marshall species, 5 were identified with fossils previously described from Rockford. Of the Huron species, 6 were identified more or less doubtfully with species from the Hamilton group of New York.

In November, Col. Jewett[64] and Professor Hall[65] both made publication of the results of late observations upon the rocks in Eastern New York, which had been embraced within the limits of the Catskill group upon the geological map of the state. Col. Jewett declared the opinion as the result of his examinations, that the Catskill group did not exist within the limits of the state; while Professor Hall admitted that the upper limit of the Chemung rocks must be carried in the Catskill mountains, "to an elevation of at least 2,000 feet above tide-water." He stated that it now becomes necessary to restrict the term *Catskill group* to the beds above [the Chemung of Delaware county, hitherto regarded as Catskill,] or to those formerly known as X and XI of the Pennsylvania Survey." He closes by remarking that "in tracing the Chemung group westward, there are many indications that it may require to be restricted in its designation," and that "the Waverly sandstone group of the Ohio reports, at one time regarded by [himself] as entirely equivalent to the Portage and Chemung groups, may, in its upper members, constitute a distinct group, though we do not yet know any line of demarkation between them."

In 1862, Professor R. Owen[66] in his Report on the geology of Indiana, ranges the shales and sandstones underneath the Mountain Limestone in a group designated after D. D. Owen, "sub-carboniferous," regarding them as at the base of the Carboniferous system, and the equivalent of at least some portion of the Waverly series of Ohio. The Black Slate he identifies with the Genesee Shale.

In January, 1863,[67] after having read Col. Jewett's announcement of the unreal character of the Catskill group, and Professor Hall's admission that this group must, at least, be very materially reduced in thickness, I gave utterance to convictions which had for some time been maturing, that not only were the Waverly rocks of the West of Carboniferous age, but that also the Chemung of New York, which Hall, White, Whitfield, Swallow, and others had persisted in identifying with these, must also be regarded as Carboniferous. I furnished a synopsis of the paleontological evidences that the Chemung, Waverly, Marshall, Rockford and Burlington beds were synchronous, and that all should be ranged within the Carboniferous system.[68]

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[63] Proc. Acad. Nat. Sci. Phil., September, 1862, p. 405. In the Sixteenth Report of the New York Regents Professor Hall has given figures of the internal structure of Centronella Julia, described in this paper, from drawings furnished by myself. He however, refers the species to Cryptonella—an error which he has since recognized. (Notice of vol. iv. of the Paleontology of New York, p. 21.)

[64] Fifteenth Report Regents New York, p. 198, and Amer. Jour. Sci., [2,] xxxiv, 418.

[65] Canadian Naturalist and Geol., vol. vii, p. 377.

[66] Indiana Geol. Rep., 1862, pp. 92, 108, &c.

[67] Amer. Jour. Sci., [2] xxxv, 61. In this paper, an editorial alteration makes me say "Old Red Sandstone of New York," when I wrote "Old Red Sandstone of Scotland."

In January, 1863,[69] I published a series of "descriptions of fossils from the yellow sandstones lying beneath the Burlington limestone, at Burlington, Iowa." The number of new species described in this paper was 59, and the number of old species there first identified from the yellow sandstones was 10—raising the total number of species thus far known from those strata from 66 to 135. The Carboniferous facies of this assemblage of organic remains was again insisted upon.[70]

Sir William Logan[71] in the Geology of Canada, published in 1863 or 1864, refers the Black Shale of Canada West to the Genesee, but states that Professor Hall embraces the Genesee in the Portage. This is what I had done in 1860.

In November, 1863, a pamphlet appeared from Professor Hall[72] containing descriptious of 17 species of crinoidea obtained from the Waverly sandstone series at Richfield, Ohio. While admitting that this assemblage of crinoids presents affinities with Carboniferous types, he asserts that the affinities are quite as strong with types from the recognized Chemung and even the Hamilton of New York. *Forbesiocrinus lobatus* is actually identified with a Hamilton species, while *F. communis*, though intimately related to forms from the Keokuk limestone, has also been found in the Chemung. He regards *Scaphiocrinus Ægina* as closely related also to *Poteriocrinus diffusus* of the Hamilton group. He concludes: "Left to the evidence afforded alone by the collection, and the means of comparison at present possessed, I should infer that the geological position of these species is between the Hamilton group and the lower Carboniferous beds; while the occurrence of a single species identical with a species in the middle of the Chemung group will ally them more nearly with the fauna of the Hamilton group than with that of the Carboniferous period."

The age of the Ohio sandstones was again touched upon by Professor Hall[73] in 1864, who thought that the study of the fossil plants of the Chemung tended to confirm opinions previously entertained as to the Carboniferous affinities of these rocks and those in Ohio, which he had regarded as contemporaneous. In a note he remarks that the Catskill rocks of Eastern New York must probably be restricted to "the coarse conglomerate of the upper part of the Catskills," which corresponds to the outliers occurring on the summits of the higher hills in Western New York, and to a continuous formation beyond the limits of the State in Pennsylvania.

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[68] The identifications with Chemung fossils had been reported by others; as at that time I had not personally examined Chemung specimens. I had identified one Avicula from Professor Hall's figure and description.

[69] Proc. Acad. Nat. Sci. Phila., Jan., 1863. p. 2.

[70] The genus *Syringothyris* established in this paper, though not accepted by Professor Hall, (Proc. Amer. Phil. Soc. May, 1866, p. 250) has been shown to be valid by the examinations of some of the highest authority in America and England. (See Meek: Proc. Acad. Nat. Sci., Dec., 1865, and——: Carpenter: Annals and Mag. Nat. Hist., July, 1867, p. 68, where the genus is partially illustrated-Davidson; Geolog. Mag., July, 1867, who gives a fully illustrated description of the genus—partly from drawings furnished by myself.) Dr. Carpenter now refers to this genus a part of *Spirifer cuspidatus* from Millicent Ireland (as first suggested by Mr. Meek;) *S. Hannibalensis* Swallow, *S. Capax*, Hall, *Syntrielasma hemiplicatus*, Meek and Worthen—also probably a portion of *Spirifer distans* of Belgium.

[71] Geology of Canada, 1863, p. 387

[72] Pamphlet; reprinted in xvii. Rep. N. Y. Reg., 1865, p. 50.

[73] xvi. Rep. N. York Regents, pp. 92 and 107. Note.

In July, 1865, I presented[74] a continuation of the results of my researches in the paleontology of the rocks under consideration, embracing descriptions and notices of fossils from the States of Michigan, Ohio, Indiana, Illinois, Iowa and Missouri, in all which I had made personal explorations. The number of species noticed in this paper is 94, of which 36 were therein first described. This paper presents a shadowing forth of conclusions which I feel constrained to think, demand the candid consideration of paleontologists. To this time I had been impressed with the expectation that the Chemung rocks of New York would eventually be synchronized with the Waverly series of Ohio upon paleontological grounds. It had generally been supposed that the Chemung strata embraced from three to six species which could be identified with western species from the horizon of the Waverly sandstone; and that on the completion of the study of these rocks by the paleontologist of New York, further identifications would be effected. At the suggestion of Professor Hall, I spent several days with him in February and March 1865, in making direct comparisons between the types of the Chemung group of New York and a collection of fossils supposed to belong to the same horizon, from the Western States. The western fossils brought under comparison numbered about 175 species. To the great surprise of both of us, we were unable to identify a single species with Chemung types. All the reputed identifications had to be abandoned. This is a conclusion in which Professor Hall united with myself.

Not satisfied to be completely frustrated in my attempt to determine the New York equivalent of our western sandstones, I turned my attention to an examination of the facts in connexion with strata occupying a position in Western New York above the typical Chemung strata. Professor Hall[75] had described a conglomerate in Western New York as terminating the Chemung series, and had remarked that it contained Chemung fossils; though it does not appear that any critical and final examination had been made upon this point. The Catskill group had been restricted at the east to certain conglomerates capping the Catskill mountains, and at the west to detached outliers of sandstone becoming also at times conglomeritic.[76] In addition to these he had described a conglomerate which he identified with the Carboniferous of Pennsylvania and Ohio[77]. It does not appear that any two of these conglomerates had been seen in juxtaposition,[78] and I am not aware of the evidence upon which they had been pronounced stratigraphically consecutive.

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[74] Proc. Acad. Nat. Sci. Phil., July, 1865, p. 109. The materials for this investigation, besides my own collections in different States, embraced Col. Whittlesey's Ohio collection and numerous residual *investiganda* of the White collection of the University, from Iowa, Missouri and Illinois.

[75] Geol. Rep. 10th Dist. N. Y., p. 252 and elsewhere.

[76] Canadian Naturalist, vii. p. 380.

[77] Rep. Geol. 10 Dist. N. Y., p, 284.

Through the kindness of Professor Hall I was permitted to examine the original specimens of fossils from the so-called Chemung and Carboniferous conglomerates. The fossils of the latter had been collected from a single locality, about four miles north of Panama in Chatauque county, and did not number in all more than half a dozen species, of which three had been described in the New York Report.[79] Of these, four were found, to the surprise of both of us, to be identical with species from the horizon of the Waverly series of the West.

Nor was this all. On comparing specimens of the so-called Chemung conglomerate with these, I remarked not only a great lithological similarity but a striking general resemblance of the fossils, and an actual identity of two species with species which had been identified in the Carboniferous conglomerate. My conclusions, so far as any could be reached, were announced in the following words :

"In the light of these identifications, and in the absence of all identifications between the western species and those of the Chemung, as well as between the species of this (so-called Chemung) conglomerate and those of the Chemung, it might not seem unreasonable to doubt its affinities with recognized Chemung rocks, and to suspect its continuity with the supposed 'Carboniferous conglomerate,' until observation shall have demonstrated that its stratigraphical position is really below that formation. And further, since we must probably abandon the attempt to coördinate the Chemung of New York with the fossiliferous portions of the sandstones and shales of the West lying between the 'Black Slate' and the Coal Conglomerate, it seems not unlikely that we may yet be able to prove the conglomerate of Western New York to be the attenuated and littoral prolongation of those western sandstones and shales—at least of the superior and fossiliferous portions of them ; so that the latter would stand as a hitherto unrecognized group of strata lying at the very base of the Carboniferous system ; while the Chemung rocks of New York fall within the Devonian system, toward which the writer is now inclined to think that their paleontological affinities attract them."

"It yet remains to determine by observations in the field, whether the so-called 'Carboniferous conglomerate' of Western New York is really the equivalent of the Coal conglomerate of Ohio ; and whether any actual junction of superposition can be discovered in Western Pennsylvania or Eastern Ohio between the Chemung rocks in their westward prolongation and the fine grained sandstones and gritstones of the Western States."

In December, 1865, Messrs. Meek and Worthen[80] described three additional species from Ohio and Illinois ; and Mr. Meek[81] took up a discussion which involved the characters and validity of the Genus *Syringothyris* from the yellow sandstones of Iowa.

In 1866 I published[82] the results of a geological and economical survey of the Grand Traverse Region in the lower peninsula of Michigan, among which I alluded to the ratification of my previous opinions that the Black Shale of the West is the equivalent of the Genesee Shale. I announced here, for the first time that this shale had afforded me two characteristic New York fossils from near the mouth of Bear Creek in Canada West—*Leiorhynchus multicosta* and *Discina Lodensis*.[83]

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[78] Hall—Rep. Geol. 10 Dist. N. Y., p. 292.

[79] Geol. 10 Dist. N. Y., p. 291.

[80] Proc. Acad. Nat. Sci. Phil., Dec., 1865, p. 245.

[81] Proc. Acad. Nat. Sci. Phila., Dec., 1865, p 275.

[82] The Grand Traverse Region, p. 51.

In this report I repeated my correction that the "green shales" above the Genesee Shale in Michigan correspond to some portion—perhaps the Cashaqua Shale—of the Portage group of New York, while the higher bluish, argillaceous shales might answer to the Chemung.

In June of the same year, having occasion to make a survey and report,[84] in conjunction with Dr. Newberry, upon portions of Knox and Coshocton counties in Ohio, I cited several Waverly sandstone species as extending upward into the Coal Measures, and suggested that the Ohio equivalent of the Portage and the Chemung might be the series of the "Chocolate Shales and Flags," whose existence beneath the fossiliferous sandstones of Ohio had been demonstrated by borings. The deepest of these borings indicated the existence of 1060 feet of shales and sandstones between the base of the False Coal Measures and the top of the Genesee Shale. Of this distance 534 feet were occupied by the so-called "chocolate shales and flags."

In July of the same year Messrs. Meek and Worthen[85] described two additional species, of which one was from Richfield, Summit county, Ohio, and the other from Rockford, Indiana.

During the same year (1866) appeared the first volume of the final Report on the geology of Illinois, in which Mr. Worthen,[86] speaking of the Kinderhook group, locates it at the base of the Carboniferous system, insists upon the carboniferous affinities of its fauna, and expresses the opinion that no rocks exist in Illinois or Indiana which can be referred to the Chemung group of New York.

Before the close of the year the second volume of this Report appeared, in which the paleontology of the Kinderhook group is described by Messrs. Meek, Worthen, and Newberry,[87] the facts of which seemed fully to sustain the previous opinions of those geologists in reference to the age of the group.

During the same year (1866) Professor Hall[88] also made advance publication of some views which were to be embodied in his fourth volume of the Paleontology of New York. In this paper he insisted with great earnestness upon the probable Chemung age of the Waverly series and its western equivalents, explaining the contrast of the eastern and western faunas on geographical and hydrographical considerations.

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[83] Mr. J. P. Lesley has somewhere attributed the discovery of these fossils to Professor Hall. It is true that I had exhibited them to Professor Hall and obtained his acquiescence in my identification, but he did not intimate that he previously observed them west of New York, Indeed, in his latest known opinion these Canadian shales had been referred to the Portage group. (Geology of Canada, 1863, p. 387.

[84] Prospectus of the Neff Petroleum Co., p. 7.

[85] Proc. Acad. Nat. Sci. Phil., July, 1866, p. 251.

[86] Geol. Survey Ill., I, p. 108.

[87] Geol. Surv. Ill. II, Paleont. pp. 62, 77, 80, 145.

[88] Trans. Amer. Philosophical Soc., 1866, p. 246; in advance of Vol. IV, Paleont. of N. Y.

In 1867, at the meeting of the National Academy at Hartford, Professor Hall reiterated the same views with considerable amplification. Professor Agassiz, who was present, gave them his earnest endorsement, pronouncing them the natural and philosophical conclusions of a geologist who had devoted 30 years to the study of the data upon which the conclusions rested. His remarks in reference to geologists who felt themselves constrained to entertain divergent opinions were at least emphatic, if they were not complimentary.

Finally in August, 1868, Dr. T. S. Hunt read a paper before the Chicago meeting of the American Association[89] in which he makes note of the occurrence, in the extreme western part of the province, of some gray and more or less blackish shales overlying the Genesee Shale proper, which he ranges in the horizon of the Portage group. It will be noticed in the sequel of this paper that I have made a similar disposition of similar strata in Michigan, Ohio, Indiana, Kentucky, and Missouri.

Such is a sketch of the history of opinion in reference to the rocks under consideration.[90]

III. PRESENT STATE OF OUR STRATIGRAPHICAL KNOWLEDGE.

In the State of New York the strata above the Genesee Shale have been arranged by Professor Hall[91] as follows :—

Carboniferous Conglomerate :—Coarse silicious conglomerate and diagonally laminated sandstone.

Catskill Group :—Conglomerate of the Catskill mountains. Along Genesee river, a calcareous sandstone, sometimes highly ferruginous, approaching iron ore.

Chemung Group :—Conglomeritic at top in Western New York. Greenish gray sandstones with occasional fossiliferous bands.

Portage Group :—A, In Eastern New York.

1. Shales and shaly sandstones and flagstones 100 feet.
2. Red shale and shaly sandstone 400 to 500 feet.
3. Greenish and gray shales and shaly sandstones.
4. Darker shales to Hamilton Group.

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[89] Published in Amer. Jour. Sci. and Arts [2] XLVI. p. 355. In this paper Dr. Hunt takes occasion to state that " Professor Winchell, for some reason, doubts the existence of the Portage formation in Ontario." As Dr. Hunt makes no reference to any published doubts entertained by me on this subject, I am at a loss to know the source of his mis-information. I have heretofore always identified with the Portage (or Portage and Chemung) the series of argillaceous strata extending from the Genesee Shale to the Marshall sandstones, (See the various references already made in this paper.) If these strata exist in Ontario I should pronounce them Portage. I have already described them upon the Michigan borders of Ontario, and it is to be presumed that they extend across the boundary. As Dr. Hunt states, these Portage shales are physically a continuation of the Genesee shale proper, and by ranging them all in my Huron group, I did in 1861, what Dr. Hunt has done in in 1866 and 1868.

[90] I have made no note of the elaborate and able researches of Dr. Dawson upon the fossil vegetation of rocks lying in and near the zone under consideration. Dr. Dawson's papers—together with some minor papers, also passed over—will be referred to in an Appendix.

[91] Final Rep. IV Dist. N. Y.; Canadian Naturalist and Geologist, vol. vii., p. 377; xvi. Report Regents N. Y., p. 107. Note.

B, In Western New York.

1. *Portage Sandstone*, thick bedded.
2. *Gardeau Shales and Flagstones*—green and black—slaty and sandy shales with thin layers of sandstone.
3. *Cashaqua Shale*—soft, argillaceous, green, crumbling to a tenaceous clay.

In Ontario, although Professor Hall and Sir William Logan have assigned at least a portion of the black shales to the horizon of the Portage Group, I have not been able to distinguish any of them from the Genesee shale proper containing *Leiorhynchus multicosta* and *Discina Lodensis.* As overlying shales of the age of the Portage Group however exist in Michigan close to the national boundary, I have always presumed that they extend across it. This opinion Dr. Hunt has very recently confirmed.

In Michigan I have been able to make out a complete determination of the strata as follows :[92]

Parma Conglomerate :—a whitish or rusty, often conglomeritic and obliquely laminated sandstone with vegetable remains. 105 feet.
Carboniferous Limestone :—irregularly bedded, often cherty or ferruginous, and much shattered *in situ*—becoming arenaceous below. 70 feet.
Michigan Salt Group :—consisting of aluminous and gypseous shales, thin gray flags, bands of limestone and thick beds of gypsum. 200 feet.
Marshall Group :—consisting of :—
  Napoleon Sandstone, pale buff, often conglomeritic, obliquely laminated, thick bedded. 123 feet.
  Marshall Sandstone, reddish, yellowish, olive, obliquely laminated, highly ferruginous—the iron often under a rudely concentric, concretionary arrangement. In places calcareous. Highly fossiliferous. 160 feet.
  Huron Gritstones, bluish or greenish gray, fine grained, regularly bedded. 15 feet.
Huron Group, consisting of :—
  Argillaceous shales and flagstones—the latter less prominent in the southern part of the State. 500 feet.
  Green arenaceous shales, especially in Grand Traverse Bay. 25 feet.
  Black bituminous shale (Genesee shale). 25 feet.
Hamilton Group. [The calcareous member of this group is conspicuous in Michigan.]

In the State of Ohio the succession of strata seems to be nearly as follows :[93]

Conglomerate, buffish, obliquely laminated, more or less pebbly, often with rudely concentric spheroids of iron ore. Sometimes underlaid by "False Coal Measures."

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[92] Mich. Geol. Rep., 1861, p. 138; Amer. Jour. Sci. [2] xxxiii., 352; The Grand Traverse Region, p. 49.

[93] Foster Geol. Rep. Ohio, p. 77; Briggs—Ib., p. 79; Whittlesey—Proc. Amer. Assoc. v. p. 76; Winchell—Mich. Geol. Rep., 1861, p. 78, also, Prospectus, Neff Petroleum Co., p. 7.

Gritstone series, consisting of flaggy shales, ferruginous, somewhat thick-bedded sandstones with iron-stone partings, often with interstratified blackish or bluish shales. Followed downward by shales of a bluish, brownish or reddish color, 100 to 150 feet.

Waverly series:—Bluish or greenish gray, fine-grained and evenly bedded, often fossiliferous sandstones and flags, with interstratified brownish shales. 200 feet. [In Knox county the Gritstone and Waverly series are together 517 feet.]

Chocolate shales, argillaceous, chocolate colored, bluish and blackish. 250 to 300 feet. [In Knox county this series is 450 feet.]

Black Shale, 100 to 150 feet. [This is an abnormal thickness of the Black Shale in the West, and it is probable the upper portion belongs with the Chocolate series.]

In the State of Indiana the series seems to be constituted as follows:[94]

Carboniferous Conglomerate.

St. Louis Limestone, freely represented.

Warsaw Limestone.

Keokuk Group, consisting of:—

Gray limestone and calcareous shales (Floyd county) 50 feet. Wanting in Northern Indiana.

Brown shales with geodes and nodules of hornstone.

Knob formation or gritstones, micaceous, ferruginous, friable, with intercalated limestones in the upper part. 150 feet or more.

Rockford Limestone, with Goniatites, &c.; represented by a thin bedded sandstone in Northern Indiana. Wanting in Western Indiana.

Black Shale.

In the State of Illinois we have the following succession of strata.[95]

Burlington Limestone.

Kinderhook Group, consisting of "gritstones, sandy and argillaceous shales, with thin beds of fine-grained and oölitic limestone." 100 to 200 ft.

Black shale. "Dark blue, green, or chocolate colored shales, passing locally into a black bituminous shale." [Presents in Southern and Western Illinois, rather the characters of the Huron shales of Michigan. May it not constitute, with the lower portion of the Kinderhook group, a representation of the Portage and Chemung of New York?]

In Iowa (at Burlington) the series of strata is the following:[96]

No. 8. Upper Burlington Limestone. 20 feet.

No. 7. Lower Burlington Limestone. 30 to 50 feet.

No. 6. Oölitic Limestone, with fossils. 2 feet.

No. 5. Yellowish Sandstone with abundant casts of Brachiopods. 4 to 6 feet.

No. 4. Limestone, with Brachiopods. 9 feet.

No. 3. Oölitic Limestone. 3 in.

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[94] Hall—Trans. Assoc. Amer. Geol. p. 280; Meek and Worthen—Amer. Jour. Sci. [2] xxxii., 167; Worthen—Ill. Geol. Report, vol. i., p. 116; Christy—Proc. Amer. Assoc., v., p. 76.

[95] Worthen—Geol. Surv. Ill., I., p. 108; III., p. 115.

[96] Hall—Iowa Geol. Rep., I., 90; White—Ib., Append.

No. 2. Bluish-brown Limestone with corals. 8 in.

No. 1. Yellowish Sandstone, passing downward into a bluish indurated clay. Fossils rare. 68 feet and more.

In Missouri we are furnished with the following series of rocks:[97]

Encrinital Limestone, regarded as equivalent to the Burlington Limestone.

Chouteau Limestone. 10 to 70 feet.

Limestone, brownish-gray, earthy, silico-magnesian, in thick beds. 40 to 50 feet.

Limestone, blue or drab, compact, thin and irregularly bedded.

Vermicular Sandstone and shales. 30 to 100 feet.

Sandstone, buff or yellowish-brown, fine-grained, argillo-calcareous. Sometimes becomes an impure magnesian limestone.

Shale or fire-clay, blue or brown, argillaceous, in regular, thin strata.

Lithographic Limestone, light drab to light buff and blue, pure, fine, compact, even-textured, silicious. 60 to 70 feet.

At bottom is a blue shale 30 to 40 feet thick.

In Kentucky, according to my own observations, we have at Knob Lick and Pine Knob, four miles south of Danville, the following section:

Sandstone, yellowish, from top of Knob down. 150 feet.

Shale, blue, arenaceous, with bands of iron ore and ferruginous sandstones, forming the phenomenon known as "Knob Lick." 80 feet. [Resembles shales of Huron Group.]

Black Shale, only moderately bituminous. 40 feet.

Silicious and Geodiferous Beds, containing *Cystiphyllum Americanum*, *Phillipsastræa gigas*, *Heliophyllum Halli*, *Fistulipora Canadensis* and other Hamilton fossils.[98]

Hydraulic Limestone, blue, arenaceous, very thick bedded, with fragments of fossils. 12 feet.

Nashville Group.

In Tennessee the Black Shale rests directly upon the Nashville group, and is overlaid by about 150 feet of the "Silicious Group," in the very lowest beds of which I have recognized *Producta semireticulata*, *Orthis Michelini*, *Spirifera Logani*, and an undescribed *Zaphrentis*, which, with the *Spirifera*, is regarded as characteristic of the Keokuk Limestone.[99] Above the Silicious group we have 394 feet of cherty limestone, mainly referable to the St. Louis division,[100] since it contains *Lithostrotion Canadense*, *Producta semireticulata*, *Streptorhynchus umbraculum*, *Spirifera Keokuk* Var, *S. perinflata?* The presence of *Rhynchonella Verneuiliana* indicates that the Warsaw limestone may also be represented in the lower portion of this formation. Next above we have 603 feet of limestone abundantly stocked with the crinoids of the Kaskaskia division of the Mountain limestone, embracing *Pentremites Godoni, pyriformis, symmetricus* and *globosus* and *Agassizocrinus gibbosus.* This section is from the eastern border of the basin of Tennessee along the road from Nashville to Sparta and the summit of the Cumberland Table Land at Bon Air.

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[97] Swallow—Neo. Geolo. Report, I., 101 and Tab. 15, p. 99; Meek and Worthen—Amer. Jour. Sci. 2] xxxii., 171.

[98] D. D. Owen speaks of no Devonian in this part of Kentucky except the Black Shale. He, however, speaks of Upper Silurian rocks; these I have not seen.

[99] These fossils were collected in Hickman and Maury counties, and kindly furnished me by Prof. Safford.

[100] In its physical characters this cherty limestone is a continuation of the Silicious Group, and Prof. Safford informs me that he so treats it in his forthcoming Report.

A black bituminous shale exists in considerable force in Carrol county and other parts of Arkansas, immediately superimposed by lower carboniferous limestones; but Dr. D. D. Owen expresses a doubt whether it answers to the Devonian Shale of Ohio; and he also doubts the existence of rocks in Arkansas corresponding to the Knob formation.[101]

In attempting to trace the parallelism of these formations on purely structural and lithological grounds, it may be remarked, in the first place, that the identity of the Black Shale cannot now be mistaken. It is a matter of no surprise that it should at any time have been referred to the horizon of the Marcellus Shale, as long as stratigraphical observations were confined to Ohio and Indiana. Its stratigraphical position above the Hamilton group is now, however, demonstrated by actual superposition in Grand Traverse Bay of Lake Michigan, Thunder Bay of Lake Huron, at various points in the peninsula of Ontario, and on the borders of the "Knob region" below Danville in Kentucky. Its position immediately below the arenaceous and argillaceous beds which are the subject of discussion in this paper, is demonstrated by the order of superposition at Pt aux Barques of Lake Huron, at sundry points in Branch, Kalamazoo and Allegan counties, Michigan, and at various places in northern and central Ohio. When at Rockford, Indiana, I had the opportunity to make my observations under favorable circumstances. The milldam had been broken away by a freshet, and the exposure of Black Shale three-fourths of a mile above was such as to indicate clearly by the dip, that this rock passes under the Goniatite limestone. My observations in this vicinity enabled me to determine the following succession of strata.

Goniatite Bed—seen below the dam and at Wilson's creek.
Semi-indurated clay.
Limestone, fine, compact but shattered, bluish, rusted in the vicinity of the fractures. Contains the Brachiopods and Radiates described from Rockford.
Black Shale.

It is further possible, as first suggested by Messrs. Meek and Worthen, that the blue shale at the base of the Lithographic Limestone in Missouri should be co-ordinated with the Black Shale. I think, however, there are reasons for considering the Genesee Shale unrepresented in Missouri.

It is proper to remark that the so-called Black Shale or "pyroschist"[102] varies very materially in the percentage of bituminous and carbonaceous matters at different localities; and the thickness of the dark bituminous beds is also extremely variable. In Michigan and Tennessee the bituminous beds are comparatively thin, but in the former State there is a vast mass of non-bituminous or slightly bituminous shales immediately overlying the lower portions, which pass by insensible gradations into the typical black shale. These, according to Hunt, occur also in Ontario. Proceeding from structural data alone, I united this entire series of shales in one formation which I styled the Huron group; and I am even now strongly inclined to associate this shale with the strata above rather than with those below. Should it be thought these facts tend to point out the equivalency of the Black Shale proper with the dark shales existing in the lower part of the Portage group of New York, it may be stated that the existence of *Lingula spatulata* in great abundance in the Black Shale of Ohio and Kentucky and the presence of *Discina Lodensis* and *Leiorhynchus multicosta* in the Black Shale of Ontario will effectually narrow the determination to the Genesee Shale of New York.[103]

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[101] Geology Reconnois. Ark. I, pp. 87, &c., and 135.

[102] Dr. T. S. Hunt proposes this Anglicised Græcism of the "Brandschiefer" of the Germans, (Amer. Jour. Sci. [2] xxxvi., 159,) since, as he asserts, this shale contains no free bitumen. In this, however, he is certainly mistaken, as I have seen it oozing from the cliffs in Grand Traverse Bay; and I am informed that the odor has sometimes attracted the attention of travelers. It appears, furthermore, that the intimate mingling of comminuted organic matters with argillaceous materials creates the most favorable conditions for the spontaneous evolution of hydrocarbonaceous products from the rocks.

In the next place, the Carboniferous Conglomerate marks a superior horizon which cannot ordinarily be mistaken. The Parma Conglomerate of Michigan, as I have heretofore indicated,[104] occupies the same stratigraphical position. The conglomerate of Western New York identified by the New York geologists with the Coal Conglomerate of Ohio, presents undoubtedly a lithological affinity. The same is true, however, of the conglomerate represented as terminating the Chemung series, and also of the conglomeratic portions of the Catskill group. I am not informed of the lithological or structural grounds upon which these three similar conglomerates (each locally varying to similar sandstones) have been ranged in an order of sequence. As they are nowhere seen in immediate superposition, it is at least supposable that they are but local occurrences of one and the same formation. If thus identifiable, the question still remains to be determined whether the formation lies in the horizon of the Chemung, in that of the Catskill or that of the Coal Conglomerate. The only evidence at present in our possession bearing upon the determination of this question is paleontological. This evidence, as I have already intimated, tends to unite the so-called Chemung and Carboniferous conglomerates and range them in a zone below the Coal Conglomerate of Ohio. This subject will be resumed in the paleontological part of this paper.

In the third place, it may be remarked that we are now in possession of the means of determining the parallelism of the western strata between the Carboniferous Conglomerate and the summit of the arenaceous series which has been locally designated Waverly, Marshall, Kinderhook, &c. The Carboniferous limestone of Michigan has been shown [105] on paleontological grounds to possess affinities with the médian stages of the Carboniferous Limestone series of the Mississippi valley. The Michigan Salt Group has at length yielded some beds of fossiliferous flags, from which, as might have been anticipated, it is shown to stand in close relation with the same series. The Knobstones of Indiana and Kentucky, always ranged by geologists within the limits of the Carboniferous system, possesses strong lithological affinities with the Waverly series, and withal occupy the same relative position between recognized Carboniferous limestones and the Black Shale. But paleontological evidence compels us to elevate them into the zone of the Mountain Limestone which, at every point of contact, is shown to lie above the Ohio psammitic series. Indeed, it appears from observations made by others and by myself, that the Knobstone formation of Indiana and Kentucky, with the associated shales and limestones, is substantially restricted to the horizon of the Keokuk division of the Mississippi Limestone series, or "Mississippi group."[106]

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[103] I desire to remark, in passing, that the Marcellus shale of New York is probably represented in Little Traverse Bay by the highly bituminous and earthy limestone near the base of the Hamilton group. The same is seen at Thunder Bay Island, Lake Huron, and in the oil wells of Enniskillen, Ontario. This shale seems therefore, like the Genesee shale, to constitute only an appendage to another formation.

[104] Michigan Geol. Rep., 1861, pp. 114, 138. So far as I know this was the first instance in which a geological designation was bestowed upon this formation. The Canadian geologists in the Report of 1863, apply the name "Bonaventure formation" to a series of arenaceous strata "belonging to the base of the Carboniferous series." (p. 404.) In the Atlas to accompany this Report, published in 1866, the Bonaventure formation is put down as the equivalent of the Coal Conglomerate of the United States.

The Silicious group of Tennessee is only a southward prolongation of the same under changed petrogenetic conditions ; though in that State, the silicious characteristics also invade the horizon of the Warsaw and St. Louis Limestones—as may be seen along the valley of the Calfkiller river, and on the first bench of the ascent to the Cumberland Table Land.

We come now to the series of strata, the determinations of whose equivalencies has presented the most serious difficulties. The Gritstones and Waverly sandstones of Ohio offer marked petrographic affinities with the arenaceous strata of the Chemung and Portage groups of New York ; and it is doubtful whether on purely lithological and structural grounds we should ever be able to distinguish them. The same may be said however, and has been said, of the Knobstones of Indiana ; and the same is also measurably true of a comparison between the Chemung and Catskill strata, or the Catskill and Millstone Grit, or the Waverly and Millstone Grit. There seems to be, moreover, a connection of continuity between the psammites of Ohio and the Chemung flags of Chatauque county. A similar petrographic resemblance is apparent between the Marshall rocks of Michigan in the northern and southern outcrops, and the Waverly of Ohio. Furthermore, no little resemblance can be traced between these sandstones and the yellow sandstones beneath the Carboniferous limestone of Iowa. The Rockford limestone and the calcareous strata of the same zone in Illinois and Missouri present considerable contrast, but they approximate, on the other hand, certain calcareous beds in the Waverly series of Summit county, Ohio. and the Marshall series of Calhoun county, Michigan. Moreover, these calcareous strata are intimately associated in Illinois and Missouri, with arenaceous strata which everywhere recall the aspect of the arenaceous strata of other States. In respect to stratigraphical position, we find all these formations lying beneath the Mississippi limestones and above the Genesee shale.

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[105] Mich. Geol. Rep. 1861, p. 103.

[106] I propose the use of this term as a geographical designation for the Carboniferous Limestones of the United States which are so largely developed in the valley of the Mississippi river.

The synchronism of the Waverly and Gritstone series of Ohio, with the Portage and Chemung of New York, has not only long been asserted—at least at invervals—by Professor Hall, but has been generally assented to by others, who have had occasion to consider the subject, or have felt disposed to defer to competent authority. The controversy which has existed has been rather in reference to the systemic position of the two, as the citations which I have already made from the history of the controversy sufficiently indicate. The Waverly series has generally been regarded of late years, as extending down to the Black Shale ; and the denial of the parallelism of this series with the Chemung and Portage has appeared to leave no space for the existence of the latter groups in Ohio. There is, as Professor Hall has frequently asserted, an improbability that a group more than a thousand feet thick in western New York, should have completely thinned out before reaching the meridian of Cleveland or the peninsula of Michigan. There are some facts in my possession, however, bearing upon this subject, which I have never yet had the opportunity to bring into prominent notice.

In my Report on the lower peninsula of Michigan I described a series of argillaceous strata[107] underneath the Marshall sandstones, and extending to the Hamilton limestones. The Genesee Shale constitutes the lower portion of this group—being structurally a portion of it. In my Report I assign but 210 feet of thickness to this group, as this was all that I had actually measured at outcrops; but borings subsequently executed in various parts of the State, show that the group actually possesses a thickness of 500 to 600 feet.[108] This mass occupies the place of the Portage and Chemung strata. In the southern portion of the State it is quite purely argillaceous, passing vertically at intervals into micaceous arenaceous shales, or even calcareo-arenaceous flags; but in its northern outcrops, we find compact flagstones frequently intercalated in the series, giving it a physical approximation to the New York strata, whose stratigraphical position it usurps. Moreover, in Grand Traverse Bay, we discover, not far above the Genesee Shale, a mass of green arenaceous shales which apparently answer to the Cashaqua Shale of the Portage group.

We have in this series all that is requisite to answer the demands of the Portage and Chemung groups. The thickness is, indeed, considerably reduced ; but it must be remembered that all the other New York groups traced into Michigan exhibit even a greater attenuation than this parallel would imply.[109]

[107] I embraced in this group 14 feet of gritstones, which I subsequently removed, on studying their paleontology. (Amer. Jour. Sci. [2] xxxiii., 352.

[108] I have several times published these later determinations, but Dr. Hunt continues to quote from my Report of 1861, (Amer. Jour. Sci. and Arts, xlvi., 357,) having evidently overlooked my later announcement. (See, for instance, "The Grand Traverse Region," (1866) p. 52.)

[109] Dr. Hunt thinks the Salina Strata will yet be found to attain a greater thickness in Michigan than that assigned to them in my Report of 1861, (Amer. Jour. Sci. and Arts, xlvi., p. 359.) The facts announced by him would certainly justify such an expectation; but I embrace the opportunity to state that though bored through in several places since the date of my Report, the thickness has not been found materially greater than stated in 1861.

Let us now inquire whether in Ohio, which lies contiguous to Michigan, anything can be discovered which answers to the Huron group. The lower portion of the series super-imposed upon the Black Slate of Ohio, has generally been passed by with the remark that it appears to be unfossiliferous, or that it *may* belong to a different epoch from the fossiliferous sandstones above. I think, however, the thickness of these subter-psammitic strata has not been generally suspected. As in Michigan, so in Ohio, we are indebted to the enterprise stimulated by the late petroleum-industry, for the disclosure of the full extent of the argillaceous and flaggy deposites immediately above the Black Shale. We are now assured of the existence of a vast series of shales in Ohio which correspond both in position and in lithological characters to the Huron group of Michigan. In Knox county they attain a measured thickness of 450 feet. Here, again, we discover ample scope of strata to answer the demands of the New York Portage and Chemung, without bringing in the Waverly and Gritstone series above.

In Kentucky also, at "Knob-lick," south of Danville, and at other points, we discover a series of argillaceous strata not less than 80 feet thick, reposing upon the Black Shale, and presenting again all the physical characters of the Huron group. As these shales are surmounted by Knobstones of Keokuk age, we have no stratigraphical determination whether they should be synchronized with the Huron group, or the Marshall, or the lower part of the Mississippi group. I think it will be admitted, however, that some presumption exists that they lie in the horizon of the Huron Shales.

In Iowa it seems not unlikely that the base of the yellow sandstone series, with its bluish, slightly micaceous sandstones, comes into the same zone ; while the blue shales, 80 feet thick, beneath the Lithographic limestone in some parts of Missouri, may probably be more correctly synchronized with the argillaceous shales of the Huron group than with the black or Genesee section of that group. I would suggest also that the Illinois shales, somewhat doubtfully referred by Prof. Worthen to the horizon of the Genesee shale, may lie rather in the horizon of the Huron shales of Michigan.

It appears from the foregoing statements that we are by no means compelled to resort to the Waverly and Marshall series to discover the western representatives of the Portage and Chemung of New York. If the apparent continuity of the eastern and western formations should appear to compel such identification, let it be remembered that the Knobstones stand in the same apparent relation to the Waverly that the Waverly does to the Chemung, and yet we yield to the weight of paleontological evidence in denying their equivalency. If, moreover, it appears that the Chemung and Portage have become finer and more argillaceous in their westward extension, it will be remembered that the Waverly strata also, when traced into Indiana, Illinois, and Missouri, have assumed a finer constitution, and have received moreover that accession of calcareous constituents which we always expect to characterize formations remoter from the ancient continental shores.[110] During the periods which followed the Genesee epoch, the time was approaching when the agitations of the terrestrial crust should culminate in the spread of thousands of square miles of coarse *débris* over the bottom of the continental lagoon of North America; the materials of the great Carboniferous Conglomerate. In the progress of the gathering convulsion, the movement of the waters had attained such a degree of violence during the period of the Portage and Chemung as to give rise to the formation of flags and sandstones within the limits of the State of New York, while yet the quieter waters which rested over Michigan and Ohio were precipitating only the materials of shales , and the regions further west were as destitute of mechanical sediments as of the organic *débris* which give origin to limestones. In the following or Marshall period, the disturbance of the terrestrial crust had attained such a limit as to give distribution to the Catskill and so-called Chemung and Carboniferous Conglomerates of New York, while in Ohio and Michigan, it attained only such a degree of energy as had been witnessed in New York during the preceding period, and resulted in the sandstones and shales of the Waverly and Marshall series. Still further West the quiet conditions of limestone-making continued to prevail. In the Knobstone epoch following this, the agitation had extended still further West. While 3,000 feet of mechanical sediments were accumulating in Pennsylvania, the conditions of sandstone accumulation had traveled towards the centre of the American lagoon as far as Indiana, Kentucky and Tennessee, while even yet, the state of quiet was sufficient in Illinois and west of the Mississippi to permit the existence of limestone making animals. The grand agitations of the Millstone grit epoch followed, with the still later oscillations of the surface which conditioned the phenomenon of the Coal epoch, terminated by the tremendous convulsions which gave birth to the mountain barriers of the Atlantic border. But none of these events were felt in the far West. Deep seas and limestone-forming operations—as Prof. Hall has well shown[111] continued to characterize the history of the interior of the continent while the coal marshes of Ohio and Pennsylvania were heaved and tossed in the titanic pastimes of geological forces.

This sketch of the succession of geological events shows that the parallelism which I have traced is in strict harmony with the method of later Paleontological Time; and instead of suggesting ábrupt disappearances and incongruous synchronisms, is the only marshalling of the American strata which keeps perfect time with the grand march of geological events.

[110] There is *a priori* evidence against the continuity of the Chemung and Waverly. Arenaceous sediments, from the circumstances and conditions of their origin, must be limited in extent, at least in one direction. We should therefore *expect* the Chemung to grow finer and to lose its physical identity in its western prolongation; and, if a sandstone recurs at the West, the immediate *presumption* arises that it is a phenomenon of changed continental conditions, characterizing another geological period. Compare Hall; Foster and Whitney's Rep. II, p. 287.

[111] Report on the Geol. and Pal. Mex. Boundary Surv. p. 124; Iowa Geol. Rep. p. 137—141.

1864. Hall: xvi. Rep. N. Y. Regents, pp. 92, 107, Note.
" Winchell: The Oil Region of Michigan (Repub. Amer. Jour. Sci., May, 1865, xxxix., 350).
1865. Winchell: Proc. Phil. Acad. Sci., July, 109.
" Meek: Proc. Acad. Nat. Sci., Phil., Dec., 275.
" Meek and Worthen: Ib., 245.
1866. Winchell: Amer. Jour. Sci., xli., 177 (March).
" Winchell: The Grand Traverse Region, p. 49.
" Newberry: Prospectus Neff Petroleum Co.
" Winchell: Prospectus Neff Petroleum Co., p. 7 (June).
" Meek and Worthen: Proc. Acad. Nat. Sci , Phil., 251.
" Worthen: Rep. Geol. Surv. Ill., I., 108.
" Meek and Worthen: Ib., II., 62, 77, 80, 145.
" Hall: Proc. Amer. Phil. Soc., 246 (in advance of Pal. N. Y.,vol.iv).
" Logan: Atlas to accompany Geology of Canada, 1863.
1867. Davidson (Thos.): Geological Magazine; vol. iv., July.
" Carpenter (W. B.): Annals and Magazine of Natural History, July.
" Meek: Amer. Jour. Sci. [2] xliii., 407.
" Hall: Notice of Volume IV., Paleontology of New York.
1868. Hall: xx. Report N.Y. Regents, p. 295, pl. ix., fig. 10.
" Winchell: Proc. Amer. Assoc., Abstract in Chicago papers, Aug.12, and "American Naturalist," Oct., p. 445.
" Meek and Worthen: Geol. Survey of Illinois, vol. III., p. 450; and also the Geology of the Counties.
1869. Safford: Geology of Tennessee, pp. 341, 439.
" Winchell: In Geol. of Tenn., pp. 364–5, 442–6.
" Winchell: Proc. Amer. Phil. Soc., xi., pp. 57–83.
" Newberry: Proc. Amer. Assoc. Salem Meeting, Relations of Ohio Geology to that of adjoining States.
1870. Hall: Preliminary Notice, &c., Preparatory for Palæntology of New York (received Jan).
" Winchell: Proc. Amer. Phil. Soc., xii., pp. 245–261 (read Jan. 4th).
" Newberry: Geological Survey of Ohio, its Progress in 1869. An Address before the Legislature (received 15 April).

ERRATA

IN PART I. OF THIS PAPER.

Page 57. Contents, v. for "analogies," read "analogues."
57. " ix., for "Their names," read "The Name."
64. Sixth line from top, for "*Gryroceras*," read "*Gyroceras*."
66. Tenth line from top, for "Hudson," read "Huron."
69. Note "70," line 3, for "authority," read "authorities."
72. Seventh line from top, for "correction," read "conviction."
72. Note "83," line 3. for "he previously," read "he had previously."
78. Note "104," line 2, for "geological," read "geographical."
80. Note "108," line 3, for "announcement," read "announcements."
82. Twenty-seventh line from top, for "phenomenon," read "phenomena."

Several minor errors will, perhaps, be apparent to the reader.